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GB 1512980

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(54) Clutch equipment for a motor vehicle

(57) The clutch releaser of a friction clutch is positionable by means of a positioning servo-drive (15, 17) in dependence upon the position of a clutch pedal detected by means of a position indicator (23). A slip regulator circuit is provided which through the positioning servo-drive (15, 17) regulates a predetermined slip of the clutch in dependence upon the engine rotation rate and the gear input rotation rate for the reduction of torsional vibrations and noises. The slip regulator circuit (51) is an averaging circuit which generates a mean value signal corresponding to the mean value in time of the rotation rate difference between the engine rotation rate and the gear input rotation rate and controls the positioning servo-drive (15, 17) in dependence upon the mean value signal. A control signal disengaging the clutch is generated when the vehicle speed is lower than walking speed and at the same time the gear rotation rate is greater than a comparatively small rotation rate value not occurring in normal driving operation, and further the clutch pedal is not actuated.

FIG. 1

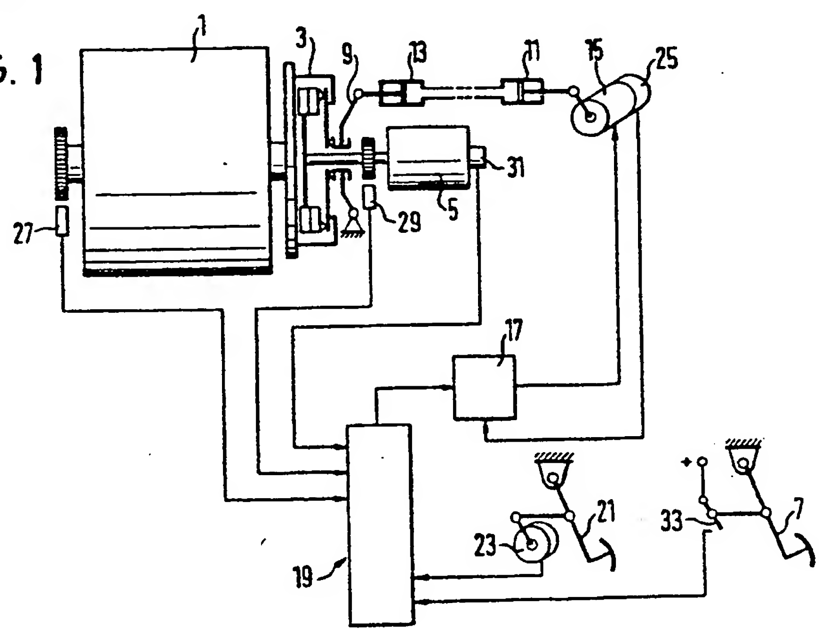

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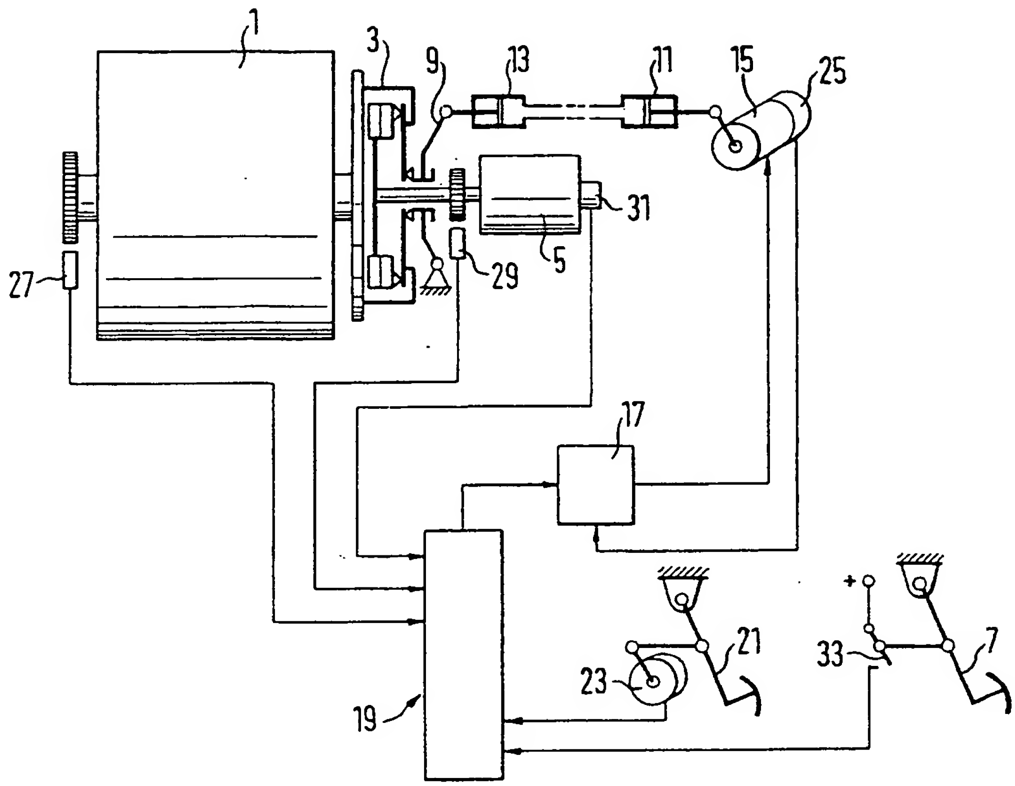
FIG. 1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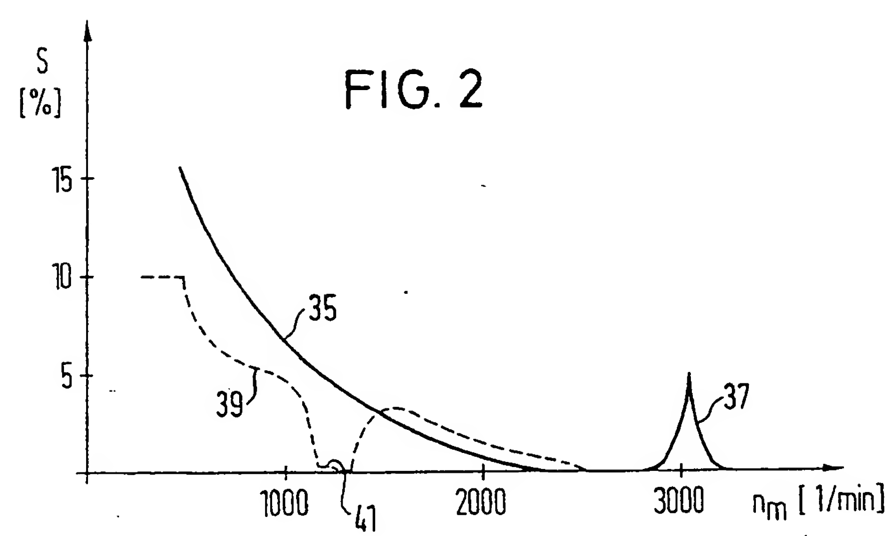
19

FIG. 2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10
5
35
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41
37
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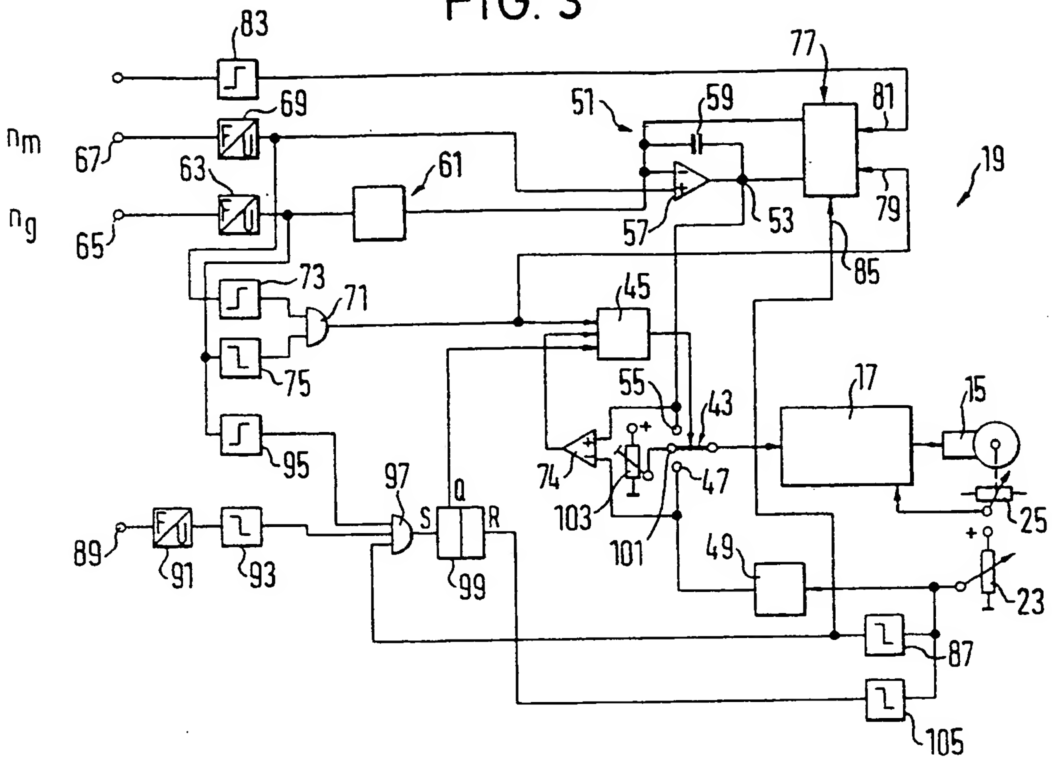
n_m [1/min]

FIG. 3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77
69
51
59
81
nm
67
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61
19
ng
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57
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79
85
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71
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55
43
17
15
74
103
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95
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Q
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89
91
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49
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87
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FIG. 4

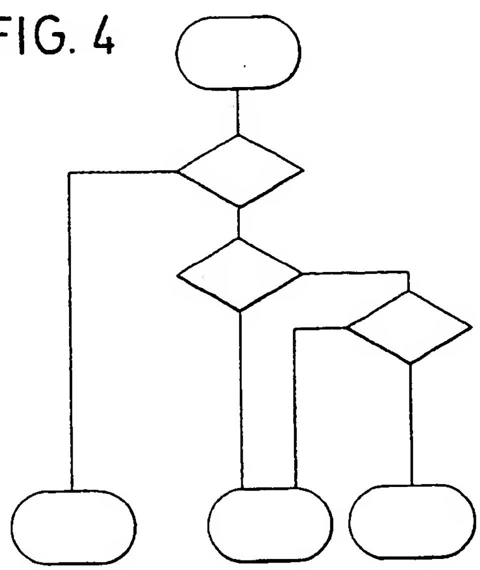
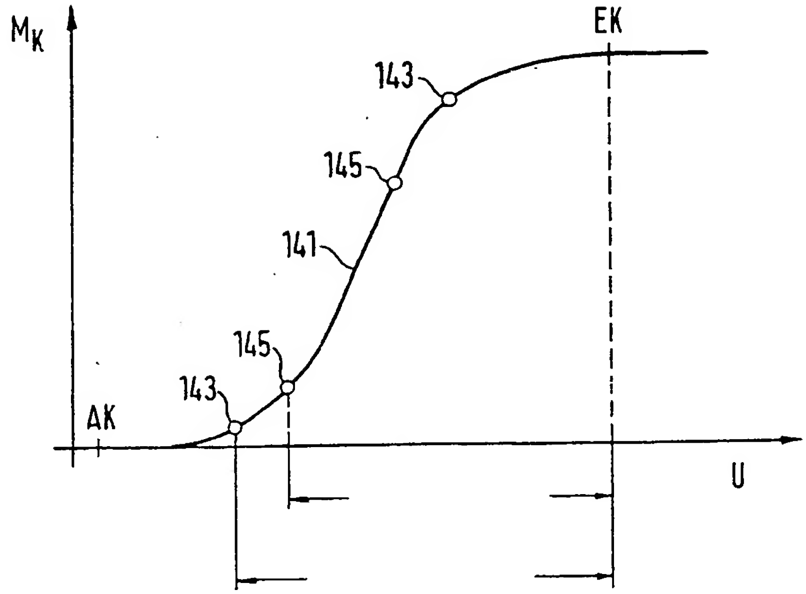
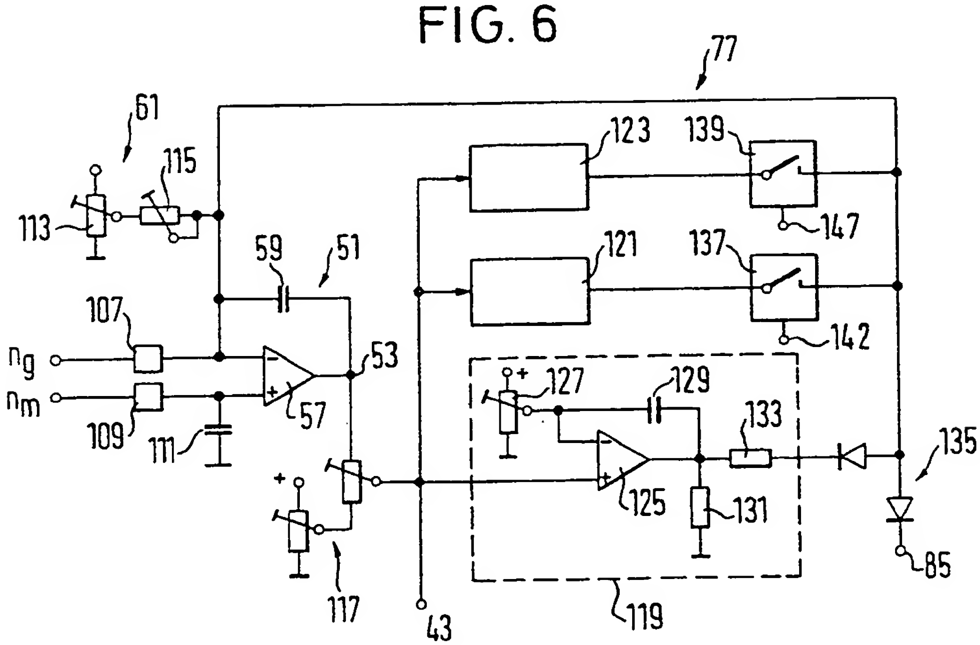


FIG. 5



M_K
EK
143
145
141
145
143
AK
U

FIG. 6



77
61
115
113
123
139
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121
137
142
59
51
107
n_g
n_m
109
111
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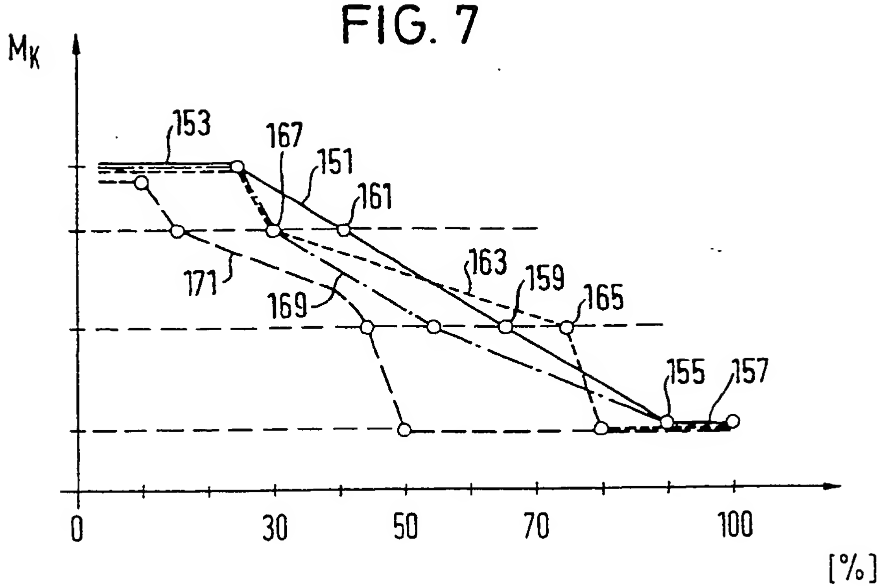
57
127
129
133
135
125
131
85
117
43
119

FIG. 7



M_K
153
167
151
161
163
159
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171
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155
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50
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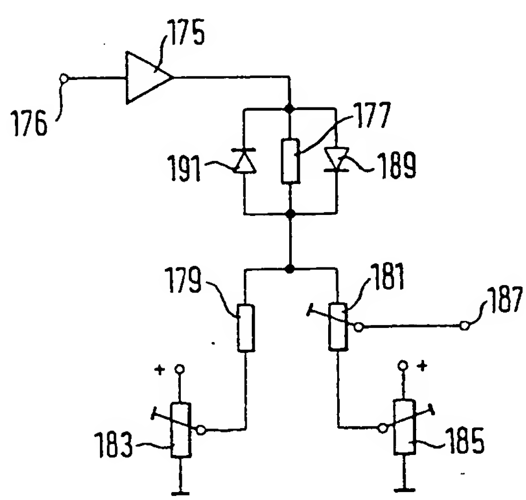
FIG. 8



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SPECIFICATION

Clutch equipment for a motor vehicle

The invention relates to clutch equipment for a motor vehicle according to the opening statement of Patent Claim 1.

In German Patent Application P 33 30 332 which is not a prior publication, clutch equipment for a motor vehicle is described in which for the damping of torsional vibrations and for the reduction of undesired noises by means of a slip-regulator circuit in dependence upon the engine rotation rate and the gear input rotation rate, the position of the clutch releaser is controlled so that even in the engaged condition the clutch works with a predetermined slip.

It is the problem of the invention to design clutch equipment in which a slip-regulator circuit ensures a predetermined slip or a predetermined rotation rate difference in dependence upon the engine rotation rate and the gear input rotation rate, in such a way that the clutch equipment satisfies the operational conditions occurring in driving operation of the motor vehicle, and at the same time rotary vibrations and operating noises are effectively reduced.

Within the scope of the invention this problem is solved in that an averaging circuit generates a mean value signal corresponding to the mean value in time of the rotation rate difference between the detected engine rotation rate and the detected gear input rotation rate and related to a time interval of constant duration, and in that the slip-regulator circuit controls the setting drive in dependence upon the mean value signal.

The invention is based upon the fact that torsional vibrations and operating noises of the clutch and gear are caused by the irregular rotation of the engine. During the working stroke of each cylinder the engine is heavily accelerated during an angle of rotation which is small in comparison with a full revolution of the crankshaft, while until the working stroke of the next cylinder it rotates with substantially uniform angular speed. These surges cause rotational vibrations and gear noises. The averaging circuit used in accordance with the invention generates an error signal in relation to a base value which represents the substantially constant angular speed between the working strokes of the cylinders. This error signal controls the setting drive of the clutch releaser and permits a uniform, overshot-free regulation of the slip. Advantages are obtained especially under operational conditions in which the clutch is already transmitting the working torque. This results in an operational behaviour in which the clutch slips only during the working strokes of the cylinders while between the working strokes it substantially does not slip. In this manner the thermal stressing of the clutch can be kept low.

The actuating device can be a conventional clutch pedal which positions the clutch releaser either through a separate setting member or through the setting member of the slip regulator circuit. The arrangement can be made so that the clutch releaser is actuated conventionally through hydraulic master and slave cylinders directly from the clutch pedal, while the setting member merely ensures an additional positioning of the clutch releaser in relation to the slave cylinder on the releaser side of the hydraulic system. In place of a clutch pedal however there may equally be an automatic clutch actuation device which controls the setting member allocated to the clutch pedal.

In a preferred form of embodiment the setting drive is a positional servo-drive which sets the position of the clutch releaser to a position fixed by an ideal position signal. The servo-drive is expediently controlled both through the slip regulator circuit and through the actuating device, for example the clutch pedal. The ideal position signals generated by the slip regulator circuit or the actuating device are standardised in mutually corresponding manner so that the servo-drive is controllable alternately either through the actuating device, that is through the clutch pedal, or through the slip regulator circuit. More especially in this manner it is possible to avoid undesired variations of position of the clutch releaser in gear changing. The slip regulator circuit is here switched off when the slip set on the clutch pedal is greater than the slip to be maintained by the slip regulator circuit at a predetermined value.

In a preferred form of embodiment the averaging circuit comprises two signal paths for the signals which represent the rotation rate difference or are used for the formation of the rotation rate difference. The one signal path contains an integrator which carries out the averaging. The other signal path has an amplification of 1 and transfers the signal representative of the rotation rate difference substantially unchanged to the output of the averaging circuit. The time constants of the two signal paths are greatly different. While the signal path containing the integrator has a high time constant, so that its output signal follows only slow variations of the rotation rate difference signal, the other signal path has a low time constant so that rapid variations of the rotation rate difference signal appear with the amplification 1 at the output of the averaging circuit. If the averaging circuit is realised by an operational amplifier the two signal paths are realised by the different time constants of the two inputs.

Especially in the case of averaging circuits assembled from active components, saturation effects can occur within the slip regulator circuit which delay the response of the slip regu-

lator circuit in the case of a variation of its input signals. In order to prevent this, in a preferred form of embodiment a limiter circuit is connected to the integrator and limits the output signals of the integrator to its proportionality range. The limiter circuit expediently not only limits the regulation range but also ensures a pre-setting of the integrator during those operating phases in which the servo-drive is controlled from the actuating device. While the actuating device is effective, the slip regulator circuit is made ineffective, as already mentioned above. Nonetheless the integrator follows the signals representative of the engine rotation rate or gear input rotation rate, in order in the transition of the guidance of the servo-drive from the actuating device, to be able to connect the slip regulator circuit as delay-freely and signal-jump-freely as possible.

Since this transition of the guidance of the servo-drive can involve a sudden variation of the position of the clutch releaser determined by the actuating device, that is the clutch pedal, and thus a sudden variation of the slip, the limiter circuit is preferably controllable in dependence upon the position of the clutch pedal or the position of an accelerator pedal in such a manner that the integrator can be made fast to predetermined values of its output signal in dependence upon the position of the clutch pedal and/or of the accelerator pedal. The output signal of the integrator can thus be set to values which reduce the slip error to be expected on a variation of these pedal positions.

In a preferred form of embodiment the slip regulator circuit comprises a slip value control circuit which controls the ideal slip value, to be maintained by the slip regulator circuit, in dependence upon the engine rotation rate. In this way it can be ensured that the friction clutch works with predetermined slip only when this is necessary by reason of the design of the engine-gear line of the vehicle. More especially mechanical resonance points of the engine gear line can be damped by resonance-type raising of the slip in the region of the resonance frequency. The slip value control circuit is expediently designed so that the slip decreases with increasing engine rotation rate and more especially has dropped to zero at a rotation rate at which the clutch is ordinarily already engaged. Apart from the already mentioned resonance rises the slip is expediently reduced to zero at a rotation rate between 2,000 and 2,600 revolutions per minute. This rotation rate range lies as a rule below the rotation rate at which the maximum engine torque results.

When the friction clutch is engaged, the engine is idling and the gear is situated in the neutral position, by reason of the non-uniformity of rotation of the engine what are called clutch or gear rattles can occur.The rattling can be prevented if with the gear in the neutral gear position the clutch is disengaged independently of the clutch actuating device, that is the pedal. The neutral gear position could be detected with a sensor on the gear, which however requires relatively high constructional expense.

A second aspect of the invention, which can also be used in clutch equipment other than that already explained, concerns the suppression of the above-explained idling rattle, without the requirement to use a sensor responding to the neutral position of the gear.

For this purpose a release control is provided which can release the clutch independently of the clutch actuating device through a setting drive, possibly the setting drive of the clutch actuating device. The release control releases the clutch when the travelling speed detected by means of a speed indicator lies in the region of a pedestrian walking speed or the vehicle is stationary, if at the same time the gear rotation rate indicator detecting the gear input rotation rate ascertains a gear input rotation rate which is greater than a predetermined rotation rate lower than the idling rotation rate of the engine and if at the same time the clutch actuating device delivers a signal which, without the release control, would control the clutch into the engagement position. If these three conditions are present the clutch is released contrarily to the engagement condition of the clutch actuating device. The gear input rotation rate monitored in this connection is made so low that with the clutch engaged under normal working conditions it cannot occur in any of the ratios of the gear without stalling the engine. A vehicle speed of less than 3 kph and a gear input rotation rate of more than 300 rpm have proved suitable values for the clutch disengagement conditions.

The release control system expediently comprises a memory which is set when the release condition is present and is cleared again through the clutch actuating device when this for its part generates an ideal position signal releasing the clutch. If for example the clutch pedal is moved into the disengagement position the guidance of the setting member transfers from the release control again to the clutch actuating device, since the memory is cleared.

A further aspect of the invention, which is likewise also of importance in other clutch equipment of motor vehicles, concerns the clutch actuation device as such. Friction clutches for high engine torques require strong clutch springs which in turn necessitate high pedal forces in the release of the clutch. In order to keep the pedal forces comparatively low, mechanical lever step-up transmissions or hydraulic step-up systems are utilised in the pedal force path. The reduction of the pedal force is however at the cost of the pedal travel which is prolonged. Therefore it is a

further problem of the invention to indicate a clutch equipment for a motor vehicle in which the pedal travel can be dimensioned in a constructively simple manner substantially independently of the actuating force necessary on the clutch release.

This can be brought about in a simple manner in that the clutch releaser is driven through a setting drive positionable by means of an electric position regulator circuit, the ideal value information of which is received from a position indicator detecting the position of the clutch pedal. An electric adaptor device with a pre-determined non-linear relationship varies the relationship between the clutch pedal position and the ideal value information, so that the sliding range of the clutch pedal, essential for the actuation of the clutch, can be especially stretched compared with conventional clutches and displaced in relation to the rest position of the clutch pedal.

In clutch position indicators which are formed as potentiometers the adaptor device can be realised in the form of a non-linear resistance characteristic of the potentiometer. The adaptor device can however also be formed as an additional non-linear circuit, for example as diode-resistance network, connected between position indicator and the position regulator circuit.

Examples of embodiment of the invention are to be explained in greater detail below by reference to drawings, wherein:—

Figure 1 shows a diagrammatic representation of clutch equipment of a motor vehicle in which the friction clutch can be loaded, even in the case of operational torque transmission, with a predetermined slip, for the reduction of irregularities of rotation and noises;

Figure 2 shows diagrams of the slip S in dependence upon the engine rotation rate n_m;

Figure 3 shows a block circuit diagram of a clutch control circuit usable in the clutch equipment according to Fig. 1;

Figure 4 shows a programme progress plan for a control logic of the circuit of Fig. 3;

Figure 5 shows a diagram showing the mean torque M_k transmittable by the clutch in dependence upon a tension U_{soll} determining the clutch position, for the explanation of a limiter circuit limiting the output signal of an integrator in Fig. 3;

Figure 6 shows a circuit diagram of the integrator and of the limiter circuit according to Fig. 3;

Figure 7 shows diagrams which show the actual position of the clutch releaser in dependence upon the pedal travel, for the explanation of a pedal travel adaptor device of the circuit according to Fig. 1, and

Figure 8 shows a circuit diagram of the pedal travel adaptor device.

Fig. 1 shows an internal combustion engine 1 of a motor vehicle which is coupled through a conventional friction disc clutch 3 with a manually changeable gear 5. An accelerator pedal 7 controls the power of the internal combustion engine 1 in a manner not further illustrated. The clutch 3 has a releaser 9 which is movable hydraulically by means of a slave cylinder 13 connected to a master cylinder 11, between an engagement position completely engaging the clutch 3 and a disengagement position completely disengaging the clutch. The master cylinder 11 and thus the clutch releaser 9 are positioned by an electric setting member 15 which is connected through a servo-regulator circuit 17 to a clutch control system 19. The clutch control system 19 responds to position signals of a position indicator 23 mechanically coupled with a clutch pedal 21, and delivers ideal position signals to the servo-regulator circuit 17 which sets the setting member 15 to a position fixed by the clutch pedal 21. To the setting member 15 for its part there is coupled a position indicator 25 which delivers actual position signals, corresponding to the actual position of the clutch releaser 9, to the servo-regulator circuit 17.

The clutch control system 19 comprises a slip regulator circuit which responds to an engine rotation rate signal, generated by means of an engine rotation rate indicator 27 and proportional to the momentary engine rotation rate or angular speed, and to a gear input rotation rate signal generated by means of a gear rotation rate indicator 29 and proportional to the momentary gear input rotation rate or angular speed, and sets the setting member 15 to a predetermined slip between engine rotation rate and gear input rotation rate. The clutch control system 19 further responds to a speed signal, corresponding to the speed of travel of the vehicle, of a speed indicator represented at 31 and detecting for example the gear output rotation rate, also a logic control signal generated by means of a switch 33 possibly in the form of a threshold value switch on deflection of the accelerator pedal 7 out of its rest position.

The slip regulator circuit increases the slip of the clutch 3, that is the difference between the engine rotation rate and the gear input rotation rate, independently of the actuation of the clutch pedal 21 to a predetermined slip value when the slip of the clutch determined by the position of the clutch pedal 21 is less than the value predetermined by the slip regulator circuit. This slip, compelled even in the case of torque-transmitting operation of the clutch, reduces the torsional vibrations and noises of the clutch 3 and the gear 5 caused by irregularities of rotation of the internal combustion engine 1. The slip regulator circuit varies the predetermined slip value S in dependence upon the engine rotation rate n_{mot}, as represented in Fig. 2. At low rotation rates the degree of non-uniformity is great and correspondingly the predetermined slip S is great.

The slip S drops with increasing engine rotation rate to zero, the slip being reduced to zero for a rotation rate at which the clutch 3 is already engaged in normal driving operation. Fig. 2 shows at 35 a typical slip-engine rotation rate characteristic curve of the slip regulator circuit which has a slip of about 10% in the case of rotation rates in the range of the idling rotation rate of the engine and reaches the value zero at a rotation rate of about 2,200 revolutions per minute. In many motor vehicles mechanical resonances occur in the drive line which considerably increase the degree of non-uniformity and the noise generation at the resonance frequency. The slip characteristic of the slip regulator circuit, as represented at 37 for a drive line resonance lying at about 3,000 rpm., can greatly increase the slip in the region of this resonance and thus ensure a reduction of the non-uniformity and noise generation. On the other hand the drive line may already be so well damped in specific engine rotation rate ranges by reason of anti-resonance phenomena that the slip of the clutch is superfluous in this range. Fig. 2 shows a slip characteristic 39 entered in chain lines in which the slip is reduced to zero in a rotation rate range 41 and initially rises with increasing rotation rate before it drops away to zero again.

In practice slip values related to the engine rotation rate, of a maximum of about 10% in the region of the idling rotation rate and a maximum 5% at about 1,500 rpm. have proved adequate.

Fig. 3 shows details of the clutch control system 19 which, as already mentioned, delivers ideal position signals to the servo-regulator circuit 17 and the setting member 15 formed as electric motor connected thereto. The position indicator 25 is formed as a potentiometer coupled with the electric motor; the position indicator 23 is likewise a potentiometer connected to a voltage source and coupled with the clutch pedal. The servo-regulator circuit 17 receives the ideal position signals through an electronic, controllable switch 43 which is controlled by a control logic 45 explained in greater detail below. The control logic 45 responds to the actuation of the clutch pedal and switches the control switch 43 on actuation of the clutch pedal into a switch position 47 in which the servo-regulator circuit 17 is connected through a pedal travel adaptor circuit 49 with the position indicator 23 of the clutch pedal and controls the setting member 15 and thus the position of the clutch releaser in dependence upon the position of the clutch pedal.

For the regulation of the clutch slip an integrator 51 is provided the output 53 of which is connected to the control switch 43 and switched to effectiveness through the control logic 45 in a switch position 55 corresponding to the slip characteristic as represented in Fig. 2. In the switch position 55 the servo-regulator circuit 17 is controlled exclusively by ideal position signals of the integrator 51 while the pedal-dependently generated ideal position signals are switched off.

The integrator 51 comprises a sum-and-difference amplifier 57 with high idling amplification of which the output forming the integrator output 53 is connected through a capacitor 59 with the inverting input. The inverting input is connected through a slip parameter adjusting circuit 61 to the output of a frequency/voltage converter 63 which receives pulse signals of the gear input rotation rate indicator 29 at its input 65. The frequency of this pulse signal is proportional to the gear input rotation rate. The engine rotation rate indicator 27 is connected to an input 67 of a frequency/voltage converter 69. The frequency/voltage converter 69 gives off at the non-inverting input of the sum-and-difference amplifier 57 a voltage which is proportional to the frequency of a pulse sequence delivered by the engine rotation rate emitter 27. The integrator 51 thus in time dependence integrates a signal corresponding to the difference of the engine rotation rate signal and the gear input rotation rate signal and thus to the momentary slip of the clutch.

In accordance with the desired slip characteristics the slip regulation should be effective only under predetermined operational conditions of the vehicle. For this purpose by means of an AND-gate 71 a logic slip control signal is generated when the engine rotation rate is greater than a predetermined rotation rate value n_{m1} and at the same time the gear input rotation rate is lower than a predetermined rotation rate n_{g1}. The AND-gate 71 is for this purpose connected through a threshold value stage 73 responding to engine rotation rate signals for rotation rates greater than n_{m1} to the frequency/voltage converter 69 and through a threshold value stage 75 responding to gear input rotation rate signals for rotation rates below n_{g1} to the frequency/voltage converter 63. The predetermined engine rotation rate value n_{m1} is lower than the idling rotation rate of the engine in order to be able to reduce noises and vibrations of the clutch or gear by means of the slip regulation even when the engine rotation rate drops during driving to values below the idling rotation rate. The value n_{m1} lies for example at about 300 rpm. The predetermined gear input rotation rate value n_{g1} lies above the idling rotation rate and preferably in a rotation rate range at which the clutch is already engaged under normal driving conditions. A suitable rotation rate value lies approximately in the range of the maximum engine torque or slightly below, for example at about 2,400 rpm. At the above-mentioned rotation rate values the slip control signal will be generated at engine rotation rate values greater than 300 rpm. and gear input

rotation rates below 2,400 rpm. The control logic 45 switches the control switch 43 into the switch position 55 in dependence upon further parameters explained below, when the engine or gear rotation rate lies within the above-stated limits and the slip control signal is generated.

The controlling of the clutch through the clutch pedal has priority over the positioning by the slip regulator circuit. A comparator 74, which is connected with its inverting input to the pedal travel adaptor circuit 49 and with its non-inverting input to the output 53 of the integrator 51, supplies a further control signal to the control logic 45 when the clutch pedal is situated in a position in which it supplies an ideal position signal for a releaser position placed closer to the completely disengaged position than the slip regulator circuit. In this case the control logic 45 switches the control switch 43 into the switch position 47 and the servo-regulator circuit 17 is guided by the pedal-dependently generated ideal position signal.

The switching over of the guidance of the servo-regulator circuit 17 from the integrator 51 to the clutch pedal-dependent guide can lead to problems when by reason of the actuation of the clutch pedal great differences of rotation rate occur between engine rotation rate and gear input rotation rate and the integrator 51 is thereby driven into saturation. If the integrator 51 has reached the state of saturation, the response of the slip regulation would be delayed until the integrator 51 returns into the proportionality range by reason of a gradually reducing rotation rate difference on its inputs. If the control switch 43 were switched into the switch position 55 while the integrator 51 is situated in the state of saturation, this would lead to an incorrect positioning of the clutch. In order to prevent this a limiter circuit 77, explained in greater detail below by reference to Fig. 6, is connected to the integrator 51. The limiter circuit 77 clamps the output voltage of the integrator 51 at values within the proportionality range of the slip regulator circuit when the slip control signal of the AND-gate 71 fed to an input 79 is absent, that is the slip control through the control logic 45 and the control switch 43 is ineffective. Furthermore a control signal representing the deflection of the accelerator pedal (7 in Fig. 1) out of its rest position can be fed at one input 81 to the limiter circuit 77. The input 81 for this purpose is connected through a threshold value stage 83 to the switch 33 of the accelerator pedal. The limiter circuit clamps the output voltage of the integrator 51 likewise at a value within the proportionality range, if the accelerator pedal is not actuated, in the presence of the slip control signal. Finally a signal representing the clutch rest position is fed to the limiter circuit 77 at one input 85. For this purpose the input 85 is connected through a threshold value switch 87 to the position indicator 23 of the clutch pedal. In the presence of the control signal representing the clutch rest position the limiter circuit 77 reduces the regulation range of the integrator 51 in the release direction.

What is called "clutch rattle" occurs with the vehicle stationary and the gear in the neutral gear position, since in this operational condition ordinarily the clutch pedal is not depressed and the clutch thus is driving the gear toothed wheels, which as a rule are positively synchronised. In order to prevent this the clutch control system 19 disengages the clutch when the vehicle is stationary and the gear in the neutral position.

The neutral position of the gear is controlled without additional sensor on the gear in dependence upon the gear transmission rate, the vehicle speed and the clutch pedal position. The speed indicator 31 is connected for this purpose to one input 89 of a frequency/voltage converter 91 which converts the pulse sequence delivered by the speed indicator 31 into a voltage signal proportional to the speed-proportional frequency of this sequence. A threshold value switch 93 delivers a first control signal when the vehicle speed is lower than a speed lying in the range of pedestrian walking speeds, for example less than 3 kph. A second control signal is generated by means of a threshold value switch 95 connected to the frequency voltage converter 63, when the gear input rotation rate is greater than a second predetermined rotation rate n_{g2}. The rotation rate value n_{g2} is so dimensioned that it cannot occur below the travelling speed detected by the threshold value switch 93 with clutch engaged in any of the gear positions except the neutral gear position. The rotation rate n_{g2} thus lies likewise below the idling rotation rate of the engine and preferably corresponds to the rotation rate n_{m1}. A suitable value for n_{g2} lies for example at 300 rpm. The signal generated by the threshold value stage 87 and representing the clutch pedal rest position serves as third control signal for the detection of the neutral gear position. The three control signals are fed to an AND-gate 97 which sets a memory 99 formed as flip-flop when the three conditions are present and thus the gear is situated in the neutral gear position. The Q-output of the memory 99 controls the switch 43 through the control logic 45 into a switch position 101 in which a voltage source 103, for example in the form of a potentiometer, delivers an ideal position signal to the servo-regulator circuit 17 which controls the setting member 15 and thus the clutch 3 into the disengaged position. The memory 99 holds the clutch 3 in the disengaged position until it is re-set. The re-setting signal is generated by a threshold value switch 105 connected to the position emitter 23 of the clutch pedal when the clutch pedal

is moved into its disengaged position. On depression of the clutch pedal the memory 99 is cleared and at the same time the switch 43 is switched over by means of the control logic 45 from the switch position 101 into the switch position 47. In the switch position 47 subsequently the clutch can be engaged by means of the clutch pedal.

Fig. 4 shows the programme course plan of the control logic 45 as it can be realised for example by switches and comparators. The disengagement condition for the neutral gear position has priority over the clutch actuation through the clutch pedal or the integrator 51. If the disengagement condition exists, the control switch 43 is switched into the switch position 101 and the clutch is disengaged. If the disengagement condition is not present, the examination for maintenance of the slip conditions takes place with next lower priority. If the slip conditions are not present, for example in the absence of slip control signal of the AND-gate 71, then the control switch 43 is switched into the switch position 47 and the clutch is controlled in dependence upon the position of the clutch pedal. If the slip conditions are present, with next lower priority it is tested whether the ideal position signal conducted by the clutch pedal or the ideal position signal conducted by the integrator effects the greater slip, that is to say represents a releaser position closer to the disengagement position. If the guidance of the servo-regulator circuit 17 lies at the clutch pedal, the control logic 45 switches the control switch 43 into the switch position 47. If the guidance of the servo-regulator circuit 17 lies by the integrator 51, the control switch 43 is switched into the switch position 55.

Fig. 6 shows details of the integrator 51, of the slip parameter adjusting circuit 61 and of the limiter circuit 77. The inputs of the sum-and-difference amplifier 57 of the integrator 51 are connected through series-resistors 107, 109 to the frequency/voltage converters 63, 69. An earthed capacitor 111 which together with the resistor 109 determines the time constant of the non-inverting input is connected to the non-inverting input. The time constant is of such short dimensions that sudden variations of the engine rotation rate n_m of the engine rotation rate signal fed to the non-inverting input appear without substantial delay on the output 53 with an amplification of 1. The resistor 107 together with the capacitor 59 determines the integration time constant of the integrator for the difference between the engine rotation rate signal and the gear input rotation rate signal. The integration time constant is considerably greater than the time constant of the non-inverting input, so that the signal at the output 53 delivers a mean value of the momentary angular speed difference of the engine rotation and the gear input shaft rotation and it is ensured that the mean value can follow slow variations of the difference occurring by reason of slow variations of the engine rotation rate averaged over one revolution. The integrator 51 thus has two signal paths between its inputs and its output and in the case of a rapid variation of the mean engine rotation rate permits a rapid, slip-dependent adjustment of the clutch position, without the occurrence of time delays by reason of the averaging properties of the integrator.

The slip parameter adjusting circuit comprises a preferably adjustable voltage source, here in the form of a potentiometer 113, which is connected through a likewise preferably adjustable series resistor 115 to the inverting input of the sum-and-difference amplifier 57. The inverting input 57 is utilised as summation point so that the integrator 51 integrates the difference of the total signal of gear input rotation speed signal and the signal of the slip parameter adjusting circuit 61 on the one hand and the engine rotation rate signal on the other hand. By means of the slip parameter adjusting circuit 61 the slip characteristic (Fig. 2) can be adjusted and especially the engine rotation rate at which the slip should be zero can be set.

The slip parameter adjusting circuit 61 superimposes upon the gear input rotation rate signal a constant or, in other forms of embodiment, an engine rotation rate—dependently varying offset voltage or an offset current. The offset voltage or current is dimensioned so that at the engine rotation rate at which the slip should be zero it compensates the gear input rotation rate signal. In the circuit arrangement according to Fig. 6 this signifies that a voltage should be set on the voltage source 113 which is equal to that generated by the frequency voltage converter 63 at the zero slip rotation rate. The resistor 115 determines the speed of variation with which the slip varies in dependence upon the engine rotation rate.

The limiter circuit 77 is connected through a bias-generating divider circuit 117 and likewise the control switch 43 is connected through a resistance divider circuit 117 with preferably variable bias to the output 53 of the integrator 51. The limiter circuit 77 comprises a plurality of selectively controllable feedback circuits 119, 121 and 123 which are connected each to the divider circuit 117 and the output signals of which feed back to the inverting input of the sum-and-difference amplifier 57. The feedback circuits 119, 121, 123 are of similar assembly so that only the feedback circuit 119 is to be explained. It comprises a comparator 125 the non-inverting input of which is connected to the resistance divider circuit 117 and the inverting input of which is connected with a preferably variable bias source 127. The output of the comparator 125 is connected through a capacitor 129 with the

inverting input. The time constant of the integrator formed in this way is less than that of the integrator 51. An output resistor 131 leading to earth and a resistor 133 leading to the inverting input of the sum-and-difference amplifier 57 are connected to the output of the comparator 125. The feedback circuit 119 is connected with the inverting input through a diode AND-gate 135 which forms the input 85 (Fig. 3) for the control signal representing the rest position of the clutch pedal. The feedback circuits 121 and 122 are connected through controllable switches 137, 139 with the inverting input of the sum-and-difference amplifier 57. The control switches 137, 139 are controllable through the inputs 79 and 81 of the limiter circuit 77.

Fig. 5 shows with a curve 141 a typical course of a torque M_k transmitted by the clutch in dependence upon a voltage U_{Soll} fed to the servo-regulator circuit 17 and forming the ideal position signal. AK designates the completely disengaged condition and EK the completely engaged condition of the clutch. 143 designates the sliding point of the clutch characterstic at which the clutch begins to transmit an appreciable torque. While the releaser position is variable according to the ideal position signal U_{Soll} between the positions AK and EK by means of the clutch pedal, the limiter circuit 77 limits the maximum range of regulation of the integrator to the ideal position signal range between the sliding point 143 and the clutch engagement position EK. The regulating range is reduced in order to prevent saturation phenomena of the integrator 51 and in order to accelerate the response of the slip regulation in the case of a deflection of the clutch pedal out of its rest position. On application of the signal representing the deflection of the clutch pedal out of its rest position to the input 85 of the diode AND-gate 135 the regulating range limit adjacent to the clutch disengagement position is raised to the engagement position, as indicated at 145 in Fig. 5.

The control switch 137 in the feedback path of the feedback circuit 121 is closed when a signal representating the absent slip signal of the AND-gate 71 (Fig. 3) is fed to its control input 142. The feedback circuit 121 then clamps the output signal of the integrator 151 at a fixed value 143 (Fig. 5) within the regulation range of the slip regulator circuit. The corresponding is valid for a further fixed value 145 with clutch further opened, when a signal is fed to a control input 147 (Fig. 6) of the control switch 139 which represents the presence of the slip signal of the AND-gate 71 and the simultaneously occurring deflection of the accelerator pedal out of its rest position. While the value 143 lies in the region of the clutch engagement position or distance from the clutch engagement position by the order of magnitude of the slip value to be maintained by the slip regulator circuit, the fixed value 145 preferably lies in the sliding range of the clutch.

The pedal travel adaptor circuit 49 as represented in Fig. 3 permits a largely variable adaptation of the pedal travel characteristic to the releaser position characteristic determining the transmitted torque of the clutch. Fig. 7 shows represented diagrammatically by a continuous line 151 the torque M_k transmitted by the clutch in dependence upon the pedal travel, which designates the rest position of the clutch pedal by 0% and the fully depressed position by 100%. After the over-coming of the idle travel 153 the transmitted clutch torque decreases until at 155 it reaches the disengaged position and is moved further over a certain safety distance 157. The engagement operation proceeds on release of the clutch pedal in the converse sequence, the sliding point being reached at 159 at which the torque transmission of the clutch commences. 161 designates the point of maximum engine torque. The pedal travel range between the points 159 and 161 is the sliding range of the clutch utilised for the engagement of the clutch. The position of the sliding range is fixed by the design of the mechanical or hydraulic clutch actuation device both as regards its position in relation to the clutch rest position and as regards its percentage width, in relation to the entire pedal travel.

The pedal travel adaptor circuit 49 permits a non-linear variation of the pedal travel-torque characteristic. 163 designates with short dashes a characteristic at which the sliding range is prolonged between a sliding point 165 and the point of maximum engine torque 167. The enlargement of the sliding range permits more finely sensitive clutch engagement. A dot-and-dash line 169 designates a characteristic at which the sliding range is displaced as a whole as regards its position in relation to the pedal rest position. A curve 171 shows with long dashes a torque-pedal travel characteristic at which the sliding range follows a non-linear curve at which the torque varies in the range of the sliding point greatly and in the range of the maximum engine moment only slightly in dependence upon the pedal travel. The curves 163, 169 and 171 furthermore show that not only can the sliding point and the point of maximum engine torque be displaced in relation to the pedal rest position, but also a prolongation of the idle movement with clutch engaged and of the safety play with clutch disengaged is possible in the end positions of the pedal.

Fig. 8 shows a simple form of embodiment of a pedal travel adaptor circuit with which linear, kinking curves according to the curves 163 and 169 can be realised. The circuit comprises an impedance converter stage 175 with low output resistance, the input 176 of which receives the position signal of the

clutch position indicator 23. An arrangement of resistors 177, 179 and 181 is connected to the output of the impedance converter stage 175. The resistors 177, 179, 181 are connected with one another. While the resistor 177 is connected to the output of the impedance converter stage 175 and thus is loaded with a voltage corresponding to the clutch pedal position, the resistors 179 and 181 are connected to preferably adjustable voltage sources 183 and 185 respectively. The voltage sources 183, 185 in the example of embodiment as illustrated are potentiometers connected between earth and an operating voltage source. The resistor 181 is in turn formed as resistance divider, here as adjustable potentiometer, and at its tapping 187 delivers the ideal position signal of the servo-regulator circuit 17 fixing the releaser position. Two oppositely polarised diodes 189, 191 are connected in parallel with the resistor 177.

The diodes 189 and 191 by their threshold voltages limit the voltage drop on the resistor 177 in which the current through the resistor 177 can vary linearly in accordance with Ohm's law. The values of the resistors 177, 179 and 181 and the biases of the voltage sources 183, 185 are so selected that the linear range coincides with the sliding range of the pedal travel.When the sliding point or the point of maximum engine torque is reached the voltage drop on the resistor 177 in each case reaches the threshold voltage of one of the two diodes and the short-circuit current flowing then through the diode short-circuits the resistor 177. Thus the voltage divider ratio, seen from the output 187, varies and correspondingly so does the steepness of the ideal position signal/pedal travel characteristic.

CLAIMS

1. Clutch equipment for a motor vehicle, comprising

a) a friction clutch (3) with a clutch releaser (9) the position of which determines the torque transmittable by the friction clutch (3),

b) a setting drive (15, 17) positioning the clutch releaser (9),

c) a clutch actuation device (21, 23, 29) fixing the position of the clutch releaser (9) selectively between a completely disengaging release position and a completely engaging engagement position,

d) an engine rotation rate indicator (27) detecting the engine rotation rate,

e) a gear rotation rate indicator (29) detecting the gear input rotation rate,

f) a slip regulator circuit (56, 61) which controls the setting drive (15, 17) in dependence upon the detected engine rotation rate and the detected gear input rotation rate in relation to the position of the clutch releaser (9) determined by the clutch actuation device (21, 23, 49) in such a way that the rotation rate difference between the engine rotation rate and the gear input rotation rate is substantially equal to a predetermined rotation rate difference,

characterised in that an averaging circuit (51) generates a mean value signal corresponding to the mean value in time of the rotation rate difference between the detected engine rotation rate and the detected gear input rotation rate, and related to a time interval of constant duration, and in that the slip regulator circuit (51, 61) controls the setting drive (15, 17) in dependence upon the mean value signal.

2. Clutch equipment according to Claim 1, characterised in that the setting drive is formed as position servo-drive (15, 17) which adjusts the position of the clutch releaser (9) to a position fixed by an ideal position signal, and in that both the actuating device (21, 23, 49) and the slip regulator circuit (51, 61) generate ideal position signals for the control of the position servo-drive (15, 17).

3. Clutch equipment according to Claim 2, characterised in that a control circuit (43, 45, 73) compares the ideal position signals of the actuating device (21, 23, 49) and of the slip regulator circuit (51, 61) with one another and switches off the ideal position signal of the slip regulator circuit (51, 61) from the position servo-drive (15, 17) when the ideal position signal of the actuating device (21, 23, 49) represents a position lying closer to the disengagement position than the ideal position signal of the slip regulator circuit (51, 61).

4. Clutch equipment according to Claim 3, characterised in that the control circuit (43, 45, 73) switches off the ideal position signal of the actuating device (21, 23, 49) from the position servo drive (15, 17) when the ideal position signal of the actuating device (21, 23, 49) represents a position lying closer to the clutch engagement position than the ideal position signal of the slip regulator circuit (51, 61).

5. Clutch equipment according to one of the preceding Claims, characterised in that the averaging circuit (51) comprises two signal paths for signals representing the rotation rate difference, of which the one signal path comprises an integrator (57, 59) for the averaging of engine rotation rate fluctuations by reason of irregularities of rotation and has a time constant which is greater, especially many times greater, than the time constant of the other signal path.

6. Clutch equipment according to Claim 5, characterised in that the averaging circuit (51) comprises a sum-and-difference amplifier (57) the inverting input of which is connected with its output through a capacitor (59) and receives a signal proportional to the gear input angular speed through an input resistor (107) and the non-inverting input of which receives a signal proportional to the engine angular speed through an RC circuit (109, 111) with smaller time constant than the time constant

effective at the inverting input.

7. Clutch equipment according to one of Claims 5 or 6 characterised in that a limiter circuit (77) limiting the output signals of the integrator (57, 59) to its proportionality range is connected to the integrator (57, 59).

8. Clutch equipment according to Claim 7, characterised in that the limiter circuit (77), in dependence upon a signal representing the absence of actuation of an accelerator pedal and/or upon a signal representing the switching to effectiveness of the slip regulator circuit (51, 61), fixes the integrator (57, 59) at a predetermined value of its output signal, if the accelerator pedal (7) is not actuated and the slip regulator circuit (51, 61) is effective or if the slip regulator circuit (51, 61) is not effective.

9. Clutch equipment according to Claim 7 or 8, characterised in that the limiter circuit (77) limits the position regulation range of the integrator (57, 59) to position values of the setting drive (15, 17) between the engagement position and a position in the region of a sliding point position representing the commencement of torque transmission of the clutch (3) and in that the limiter circuit (77) responds to a signal which represents the positioning of the clutch releaser (9) by means of the actuating device (21, 23, 49) at a position departing from the clutch engagement position and upon this signal limits the range of regulation of the integrator (57, 59) to position values between the engagement position and a position between the engagement position and the sliding point position.

10. Clutch equipment according to one of the preceding Claims, characterised in that the slip regulator circuit (51, 61) comprises a slip value control circuit (61) varying the predetermined rotation rate difference in dependence upon the engine rotation rate.

11. Clutch equipment according to Claim 10, characterised in that the slip value control circuit (61) reduces the predetermined rotation rate difference to zero with increasing engine rotation rate.

12. Clutch equipment according to Claim 11, characterised in that the slip value control circuit (61) reduces the predetermined rotation rate difference to zero in a range of engine rotation rate between 2,000 and 2,600 revolutions per minute.

13. Clutch equipment according to one of Claims 10 to 12, characterised in that the slip value control circuit (61) over-raises the predetermined rotation rate differences in resonance manner in the range of mechanical resonance frequencies of the engine-gear line.

14. Clutch equipment according to one of Claims 6 to 9 and one of Claims 10 to 13, characterised in that the slip value control circuit (61) comprises two series resistors (107, 115) connected each with a first connection to the inverting input of the sum-and-difference amplifier (57), of which resistors the one is coupled with its second connection with the gear rotation rate indicator (29) and the other with its second connection with a voltage source (113) and in that the voltage source (113) and the gear rotation rate indicator (29) generate equal currents on the second connections of the two series resistors at that engine rotation rate at which the predetermined rotation rate difference is zero.

15. Clutch equipment according to one of the preceding Claims, characterised in that the slip regulator circuit (51, 61) comprises a control stage (71, 73, 75) responding to the detected engine rotation rate and the detected gear input rotation rate, which control stage switches the slip regulator circuit (51, 61) to effective when the engine rotation rate is greater than a first predetermined rotation rate value which in turn is less than the idling rotation rate of the engine and at the same time the gear input rotation rate is less than a second predetermined rotation rate value which in turn is greater than the idling rotation rate of the engine and switches the slip regulator circuit (51, 61) to ineffective when the engine rotation rate is less than the first predetermined rotation rate value or when the gear input rotation rate is greater than the second predetermined rotation rate value.

16. Clutch equipment according to Claim 15, characterised in that the first predetermined rotation rate value lies in the range of 300 revolutions per minute and the second predetermined rotation rate value lies in the range of 2,400 revolutions per minute.

17. Clutch equipment for a motor vehicle, comprising

a) a friction clutch (3) with a clutch releaser (9) the position of which determines the torque transmittable by the friction clutch (3),

b) a setting drive (15, 17) positioning the clutch releaser (9),

c) a clutch actuation device (21, 23, 29) determining the position of the clutch releaser 9) selectively between a completely disengaging release position and a completely engaging engagement position,

d) an engine rotation rate regulator (27) detecting the engine rotation rate, especially according to one of Claims 1 to 16, characterised in that a speed indicator (31) responding to the vehicle speed is provided which generates a first signal representing the halting of the vehicle or vehicle speeds in the range of pedestrian walking speeds,

in that the clutch actuation device (21, 23, 49) in the case of presence of its ideal position signal fixing the clutch engagement position generates a second signal representing this operational condition,

and in that a disengagement control system (97, 99, 103) generates an ideal position signal controlling the setting drive (15, 17) independently of the clutch actuation device (21,

23) into the disengagement position when the first and the second signal are present and the detected gear input rotation rate is greater than a predetermined rotation rate value which in turn is less than the idling rotation rate of the engine.

18. Clutch equipment according to Claim 17, characterised in that the disengagement control system (97, 99, 103) comprises a memory (99) which is set in the presence of the disengagement condition and holds the servo-drive (15, 17) in the disengagement position and in that the clutch actuation device (21, 23) in the presence of its ideal position signal fixing the disengagement position generates a third signal representing this operational condition and feeds it to the memory (99) for the clearing of the stored disengagement condition.

19. Clutch equipment for a motor vehicle, comprising

a) a friction clutch (3) with a clutch releaser (9) the position of which fixes the torque transmittable by the friction clutch (3),

b) a setting drive (15, 17) positioning the clutch releaser (9).

c) a clutch pedal (21),

d) a position indicator (23), controlling the setting drive (15, 17) and coupled with the clutch pedal (21), especially according to one of the preceding Claims,

characterised in that the position indicator (23) generates an electric control signal representing the position of the clutch pedal (21), in that an electric adaptor device (49) is provided which fixes a predetermined non-linear relationship between the position of the clutch pedal (21) and the control signal and in that the setting drive (15, 17) comprises an electric position regulator circuit (17) which adjusts the position of the clutch releaser (9), through an electrically controllable setting member (15), to a position fixed by the control signal as ideal value information.

20. Clutch equipment according to Claim 19, characterised in that the position indicator (23) is formed as potentiometer which has a non-linear resistance characteristic for the formation of the adaptor device.

21. Clutch equipment according to Claim 19, characterised in that the adaptor device (49) is formed as diode-resistance network (177, 179, 181, 189, 199) and is connected between the position indicator (23) and the position regulator circuit (17).

22. Clutch equipment according to Claim 21, characterised in that the diode resistance network is formed as resistance divider circuit (177, 179, 181) and in that at least one diode, preferably two oppositely polarised diodes (189, 199), is or are connected in parallel with at least one of the resistors (177) of the resistance divider circuit (177, 179, 181).

23. Clutch equipment for a motor vehicle as claimed in Claim 1, substantially as herein described with reference to and as illustrated by any one of the examples shown in the accompanying drawings.

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